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(71) Applicant: **Pasqualini, Piero**
Piazza Esquilino, 9
I-20148 Milano(IT)

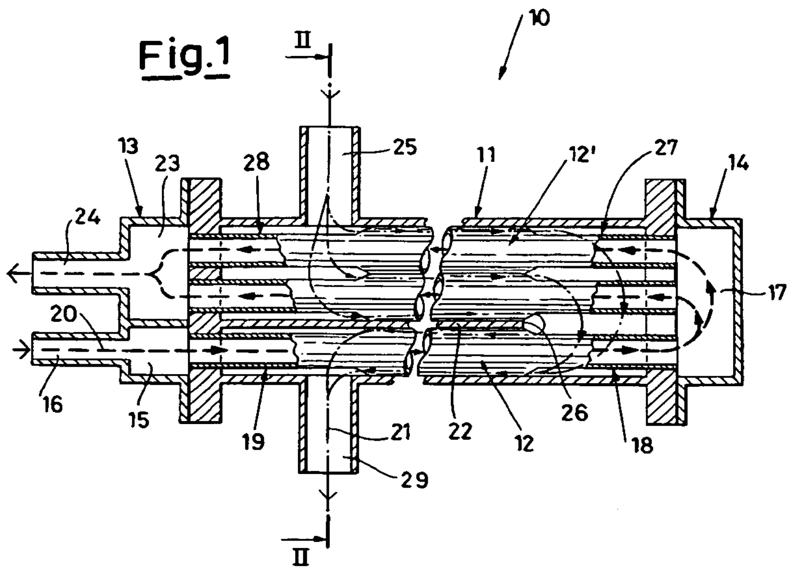
(72) Inventor: **Pasqualini, Piero**
Piazza Esquilino, 9
I-20148 Milano(IT)

(74) Representative: **Faraggiana, Vittorio, Dr. Ing.**
Ingg. Guzzi e Ravizza S.r.l. Via Boccaccio, 24
I-20123 Milano(IT)

(54) **Heat exchangers for fluids.**

(57) A heat exchanger device (10) comprises bundles (12, 12') of parallel tubes traversed by a first fluid and contained in a casing (11) through which flows a second fluid. The tubes in the bundles (12, 12') open out into end chambers (15, 17, 23) of the casing, which constitute series connections between the bundles and inlet and outlet pipes of the first fluid from the exchanger (10). The tubes in the bundles are disposed within the casing (11) closely adjacent to one another and to the walls of the casing and have end portions with a smaller sectional area of flow to create manifolds (18, 19, 27, 28) in the casing for the second fluid, which constitute the interconnection of the spaces between the tubes and connections for the inlets (25) and outlets (29) for the circulation of said second fluid.

Fig.1



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In the field of heat exchangers for fluids there are various known embodiments which attempt to reconcile heat exchange efficiency with structural simplicity and low manufacturing and, wherever possible, maintenance costs.

For example, there are known heat exchangers consisting of first ducts traversed by a first fluid and disposed coaxially inside second ducts, a second fluid flowing through the space between the first and second ducts, thus achieving a high degree of heat exchange between the first and second fluid. It will, however, be obvious to the technician that an embodiment of this kind is expensive and difficult to manufacture. In fact, in order to limit the dimensions of the heat exchanger, the ducts must be bent to form a succession of parallel segments which entails considerable problems in achieving the bends. In order to reduce manufacturing problems it has also been suggested to make the outer ducts in segments disposed over the straight sections of the inner ducts, between two consecutive bends, to weld the segments at the ends to make them watertight and, lastly, to interconnect them to each other by means of further ducts. An embodiment of this kind, however, is always rather expensive.

Heat exchangers have also been proposed in which the coaxial ducts are a plurality of parallel segments provided at the ends with suitable connecting plates to connect both the various internal ducts and the various outer ducts in order to achieve the two separate streams of fluid. These embodiments also involve manufacturing problems due to the complex assembly of a large number of coaxial segments.

To overcome assembling problems, further heat exchangers have also been proposed with ducts for the fluids disposed side by side and in contact with one another instead of concentrically. These exchangers have the disadvantage, however, of being less efficient, even though they still remain quite complex to assemble.

There are also known exchangers in which the tubes traversed by a first fluid are disposed inside a container traversed by the second fluid. These embodiments have the drawback of not keeping the flow of the second fluid perfectly parallel with the tubes inside the container and, moreover, are not easy to manufacture with regard to the uniform inflow and outflow of the first fluid, without giving rise to hot spots, which are detrimental to the heat exchange process.

A further problem, common to the great majority of exchangers, is the considerable weight and extensive use of materials required to obtain the passages for the various fluids, especially in the event of a plurality of fluids. In the case of exchangers made of valuable materials, which are necessary, for example, for highly aggressive fluids, this also means very high costs.

Lastly, due to their complexity, the known heat exchangers are not sufficiently flexible in structure to readily adapt to the different practical requirements in the field.

The general scope of this invention is to obviate the aforementioned problems by providing a heat exchanger of limited structural complexity, weight, overall dimensions and cost, with high heat exchange efficiency and a high degree of structural versatility.

This scope is achieved according to the invention, by providing a heat exchange device comprising at least one heat exchange element, in turn comprising at least one bundle of parallel tubes traversed by a first fluid and contained in a casing through which flows a second fluid, the tubes opening out into end chambers of the casing, which constitute connections for the inlet and outlet of the first fluid from the bundle of tubes, characterized by the fact that the tubes in said bundle are disposed in the casing closely adjacent to each other and to the walls of the casing and have end portions with a smaller cross section to create manifolds in the casing for the second fluid, into which open out inlets and outlets for the circulation of said second fluid.

The innovatory principles of this invention and its advantages with respect to the known technique will be more clearly evident from the following description of a possible exemplificative embodiment applying such principles, with reference to the accompanying drawings, in which:

- figure 1 shows a longitudinal partial cutaway view, generically viewed along the line I-I of figure 2, of an exchanger according to the invention;
- figure 2 shows a cross-sectional view along the line II-II of figure 1.

With reference to the figures, a heat exchanger according to the invention, generically indicated by reference 10, comprises a casing 11 within which is disposed a first bundle of parallel tubes 12. The tubes have ends which pass through the ends of the container 11 and open out into end chambers defined by airtight covers 13 and 14.

For example, the cover 13 defines a first chamber 15 for the common connection of one end of the bundle of tubes 12 to provide a common inlet for a first fluid, while the cover 14 defines a chamber 17 for the common connection of the other end of the bundle 12 to provide a common outlet for the first fluid from the bundle. The covers 13 and 14 can be either made removable, for example, to allow inspection of the inside of the exchanger, or can be made in one piece with the casing 11, closed by welding or the like.

The tubes in the bundle are disposed close together. For example, as can be clearly seen in figure 2, the tubes can advantageously have a circular cross-section and can be in peripheral contact with each other along generatrices.

Likewise, the peripheral portion of the bundle is disposed close to the side walls of the casing, for example in contact with them.

Interspaces are thus defined between the tubes parallel to their extension.

Innovatively, close to their ends the tubes have a smaller cross-section to create manifold areas or chambers 18 and 19 for the inlet and outlet of a second fluid which is made to flow through the casing.

In this way it is possible to obtain a stream of the first fluid in the tubes and an effectively parallel stream of the second fluid in the interspaces. For example, the two streams can flow as shown schematically by the broken line for the first fluid in 20 and by the line of dots and dashes in 21. These streams advantageously flow in opposite directions to create a counterflow heat exchanger. The surface of the tubes thus constitutes the heat exchange wall between the fluids.

The peripheral contact between the tubes offers the further advantage of preventing the occurrence of vibrations in them caused by the fluid flowing through them.

The basic heat exchange element described above can be connected in series to other similar elements to obtain exchange devices with higher performances.

For example, the figures show a second bundle of parallel tubes 12' disposed within a shell made in the casing 11 by means of a baffle separating them from the bundle 12.

The tubes 12' are disposed and shaped substantially similarly to the tubes 12. Therefore they have ends with smaller cross-sections to define manifold chambers 27 and 28 within the shell. The baffle 22 has an aperture 26 which constitutes a passage between the manifold chamber 18 of the bundle 12 and the adjacent manifold chamber 27 of the bundle 12'. An inlet pipe 25 leads into the manifold chamber 28.

The tubes 12' also have ends which pass through the ends of the casing 11 and open out into end chambers defined by the airtight covers 13 and 14.

In particular, the chamber 17 of the cover 14 provides an interconnecting passage between one end of the bundle of tubes 12' and one end of the bundle 12 for passage of the first fluid. The cover 13 defines a further interconnecting passage 23 for the other end of the bundle 12' to create an outlet for the first fluid through an outlet pipe 24.

Hence the first fluid, fed into the heat exchange device 10 through the inlet pipe 16 in the cover 13, flows through the first bundle 12, converges in the chamber 17, flows through the bundle 12', into the chamber 23, and hen out of the exchanger through the outlet pipe 24, thus creating a first path for the circulation of the first fluid, as shown by the broken line 20 disposed between the inlet pipe 16 and outlet pipe 24.

The second fluid, which is fed into the exchanger 10 through the lateral inlet pipe 25, flows through the interspaces between the tubes, converges in the manifold chamber 27, and then flows through the aperture 26 in the baffle 22 and into the manifold chamber 18. From the manifold chamber 18, the fluid then flows through the interspaces parallel to the tubes 12 and into the manifold chamber 19, and then out of the latter through an outlet pipe 29, thus creating a second path for the circulation of the second fluid, as shown by the lines of dots and dashes 21 disposed between the inlet pipe 25 and outlet pipe 29.

In practice, the inlet and outlet pipes 16, 24, 25, 29 will obviously be connected to known types of fluid circulation systems.

It will be obvious to the technician that a high degree of efficiency can thus be achieved, since the exchanger is in fact a parallel-flow exchanger, without cross-flows, of limited structural complexity and with a limited need for material. This makes it possible to achieve lower costs and weight and smaller overall dimensions.

The mingling which takes place close to the end chambers for the first fluid, and close to the manifold chambers for the second fluid, ensures an even distribution of the temperature of the fluids, without hot spots and pockets.

The foregoing description of an embodiment applying the innovatory principles of this invention is obviously given merely by way of example in order to illustrate such innovatory principles and should not therefore be understood as a limitation to the sphere of the invention claimed herein.

For example, the number of tubes making up each bundle may differ from that shown according to the particular properties of the fluids used and of the exchange of heat to be obtained. In the exemplificative embodiment described above, the inlet bundle 12 has a smaller number of tubes than the outlet bundle 12', so that the exchanger is particularly suitable for treating fluids which expand considerably in volume during heat exchange.

This does not exclude the possibility of other possible ratios between the number of tubes in the various bundles.

Likewise, the number of exchange elements disposed in series can be more than two. It will be obvious to the technician that the structure shown can be easily enlarged, either by using elements

each with its own casing and connected in series by means of external ducts or by using elements combined together in a single casing with dividing baffles between them and end chambers in common. It is also easy to imagine that separate paths can be obtained for a plurality of first fluids and a plurality of second fluids by the interposition of suitable baffles between the tubes in the bundles. For example, by dividing the inside of the casing 11 into two parts by means of a dividing baffle, disposed as shown by the broken line 30 in figure 2, it is possible to obtain two separate paths for two second fluids, (obviously entering and leaving the casing through a separate inlet and outlet as also schematically shown by the broken line 30), which exchange heat with a single first fluid circulating through the tubes.

Likewise, by dividing the end chambers by means of suitable baffles, so as to isolate groups of outlets at the ends of the tubes, it is possible to obtain two or more paths for a plurality of first fluids, entering and leaving the end chambers through separate inlet and outlet pipes.

It will therefore be clearly evident to the technician that the innovative technique of constructing a heat exchanger as shown and described herein offers such a high degree of flexibility in its manufacture, as to enable it to adapt to the most diverse requirements.

Claims

1. Heat exchanger device comprising at least one heat exchange element, in turn comprising at least one bundle of parallel tubes traversed by a first fluid and contained in a casing through which flows a second fluid, the tubes opening out into end chambers of the casing, which constitute connections for the inlet and outlet of the first fluid from the bundle of tubes, characterized by the fact that the tubes in said bundle are disposed in the casing closely adjacent to each other and to the walls of the casing and have end portions with a smaller cross section to create manifolds in the casing for the second fluid, into which open out inlets and outlets for the circulation of said second fluid.

2. Device as claimed in claim 1, characterized by the fact that the tubes in each bundle have a generically circular cross-section and are grouped together substantially in contact along generatrices.

3. Device as claimed in claim 2, characterized by the fact that the peripheral tubes of the bundle are substantially in contact along generatrices with the side walls of the casing containing the bundle.

4. Device as claimed in claim 1, characterized by the fact that the end chambers are defined by hollow covers fitted onto the end walls of the casing, said walls being crosswise to the extension of the tubes and provided with holes traversed by the corresponding ends of the tubes.

5. Device as claimed in claim 2, characterized by the fact that said generatrices of contact of each tube with the other tubes are contained in planes perpendicular to each other and crossing the axis of the tubes.

6. Device as claimed in claim 1, characterized by the fact of comprising a plurality of heat exchange elements, whose bundles of tubes are connected in series by means of first connecting passages in the end chambers for consecutive elements, the casings being connected in series by means of second passages between the manifold chambers for consecutive elements.

7. Device as claimed in claim 6, characterized by the fact that the casings of the bundles of tubes of the plurality of heat exchange elements are made of a single container divided longitudinally by baffles each constituting a side wall shared by two consecutive heat exchange elements, disposed side by side, each baffle having an end aperture which constitute the second communicating passages between said two exchangers.

8. Device as claimed in claims 4 and 7, characterized by the fact that the first passages between two consecutive elements are made with a cover shared by said two elements.

9. Device as claimed in claims 4 and 7, characterized by the fact that the covers on the same end of the container are made together in one piece.

10. Device as claimed in claim 1, characterized by the fact that the inlets and outlets for the circulation of the second fluid comprise connections on the side of the casing for ducts for the circulation of said second fluids.

11. Device as claimed in claims 4 and 6, characterized by the fact that the cover defining the inlet chamber of the first element of the plurality and the cover defining the outlet

chamber of the last element of the plurality comprise, respectively, connections for the inlet and connections for the outlet of said first fluid from the heat exchange device.

12. Device as claimed in claim 1, characterized by the fact that bundles of tubes are separated from each other by baffles in the casing in order to obtain separate portions of the casing for the flow of more than one second fluid, said portions each having its own manifold chambers.

13. Device as claimed in claim 1, characterized by the fact that the chambers are divided by baffles dividing the ends of the tubes into groups, each group for one fluid of said first fluids.

14. Device as claimed in claim 6, characterized by the fact that said plurality of heat exchange elements is composed of two heat exchange elements.

15. Device as claimed in claim 1, characterized by the fact that the first fluids flow through the tubes in the opposite direction to the direction of flow of the corresponding second fluids through the casing.

16. Device as claimed in claim 1, characterized by the fact that the casing is substantially prismatic in shape, in particular parallelepipedal.

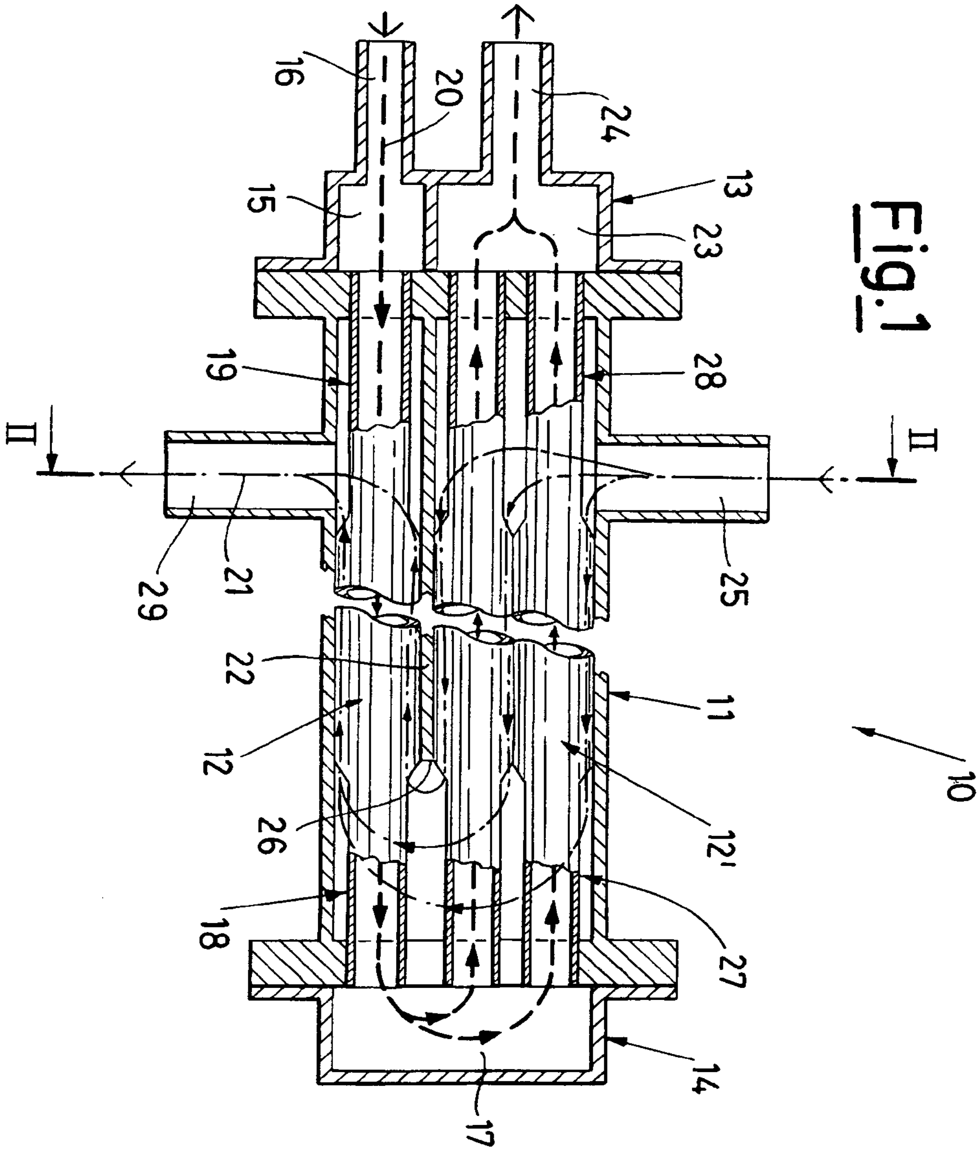
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Fig.1

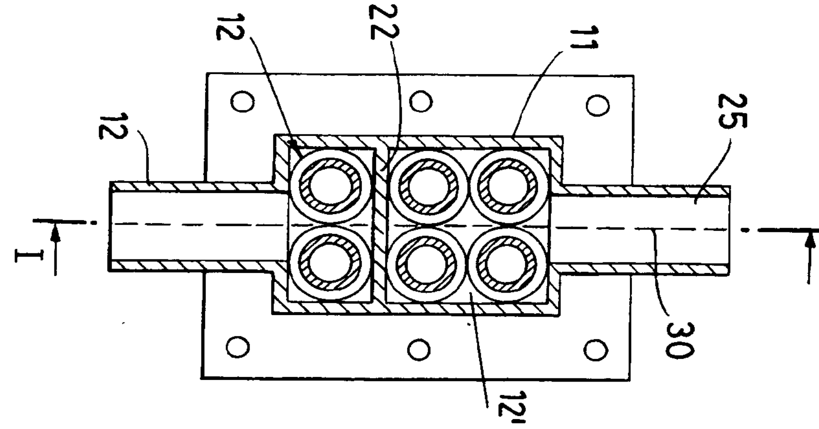
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Fig.2

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EUROPEAN SEARCH REPORT

Application Number

EP 92 20 0714

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
X	US-A-1 946 234 (PRICE)	1,4,6, 10,14,15	F28D7/16 F28F13/08
Y	* the whole document *	2,3,8,9, 11,12,16	

Y	CH-A-402 910 (GEBRÜDER SULZER AG) * claim 1; figures *	2,3	

Y	FR-A-2 297 395 (SA DES ETABLISSEMENTS NEU)	16	
A		1,2,3	

Y	US-A-1 759 360 (LIFUR)	8,9,11, 12	
	* the whole document *		

X	DE-C-854 224 (KÖHLER) * the whole document *	1	

TECHNICAL FIELDS SEARCHED (Int. Cl.5)
F28D
F28F

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	24 JUNE 1992	VAN GESTEL H.M.

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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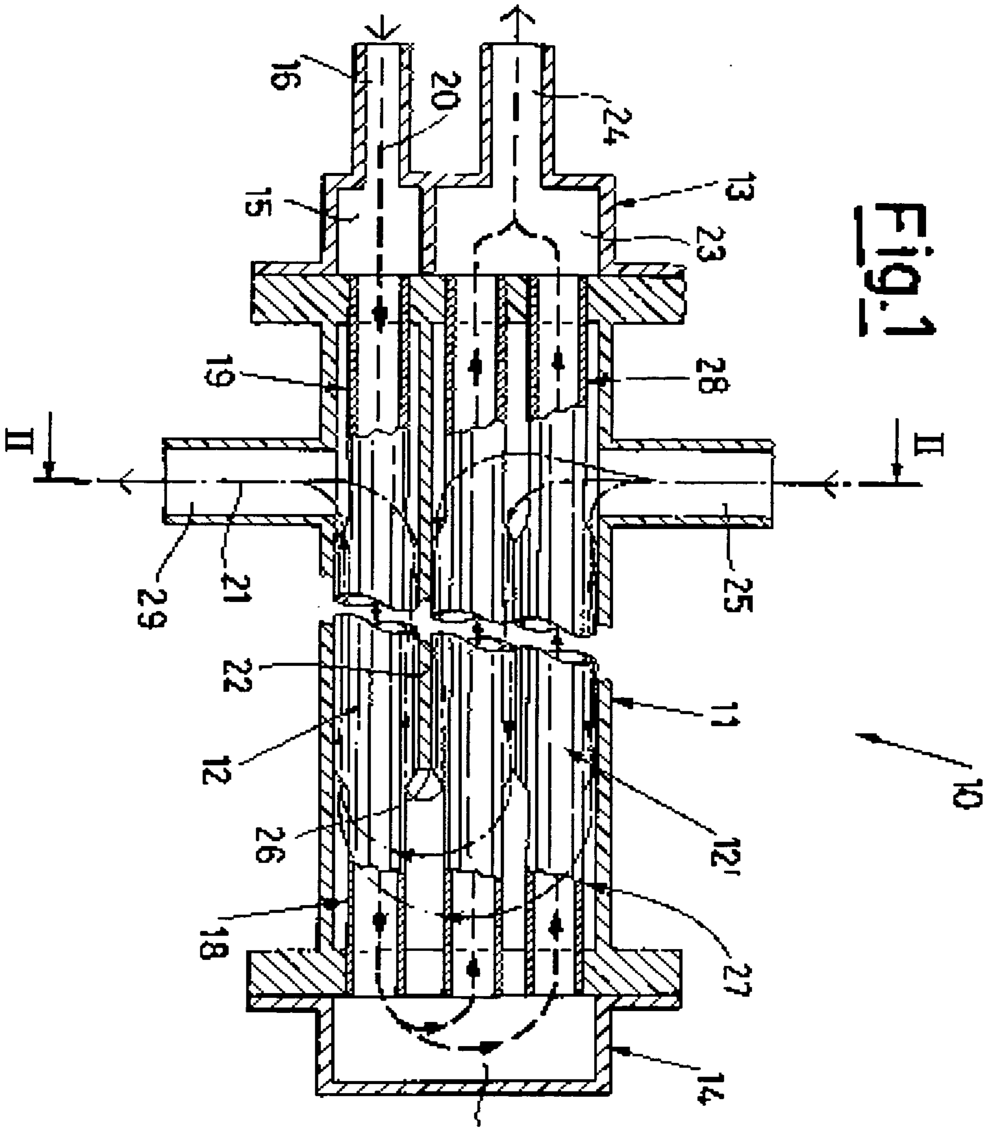
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Fig.1

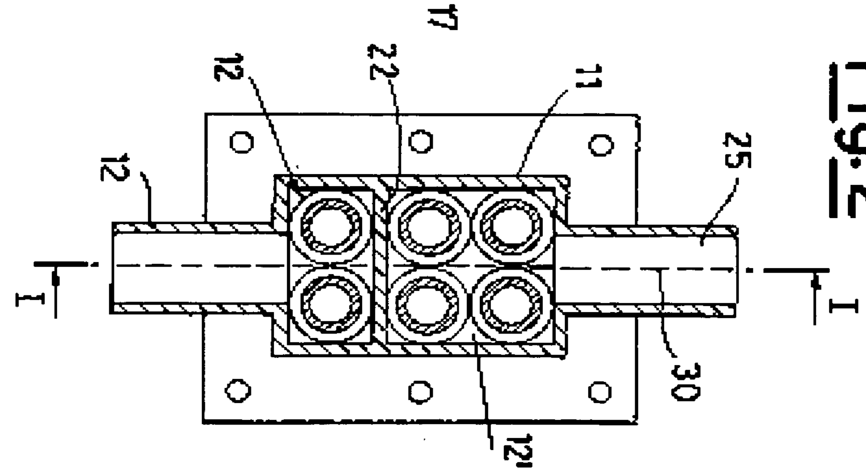
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Fig.2